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QUANTITATIVE ARGUMENTS ON WHETHER STRONG-MOTION OCEAN BOTTOM SEISMOGRAPHS ARE WORTH INSTALLING FOR EARTHQUAKE SOURCE STUDIES

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1. INTRODUCTION

Although local site effects on strong-motion records have been undoughedly verified by numerous studies, only very few studies have been done to investigate source effects that corrspond to damage and intensity patterns. One of such studies was done by Hartzell and Iida (JGR, 1990). They demonstrated source effects on one of the best instrumented earthquakes to date using a source inversion method which had been basically developed by Hartzell and Heaton (BSSA, 1983). The 1987 Whittier Narrows, California, earthquake with a local magnitude of 5.9 provided us with strong-motion records at 17 near-source stations that formed good azimuthal coverage of the source to give good resolution (Iida, EESD, 1990). Because of the difficulty in modeling very high frequencies, band-pass filtered velocity records from 0.2 to 3.0 Hz were inverted to obtain the history of slip. The results showed that the ground motions could be considerably explained by only source effects.

2. PURPOSES

When we consider large source effects on strong-motion records, land stations alone do not seem to be effective to investigate the rupturing process of offshore events. However, no quantitative arguments on whether Strong-Motion Ocean Bottom Seismographs (SM-OBS) are worth installing have yet been made. In order to demonstrate or refute their necessity, we will investigate the contribution of hypothetical SM-OBSs to source studies for the 1968 Tokachi-oki and anticipated Tokai earthquakes (Iida et al., JPE, 1990 = Paper A), and will also conduct a general test of the relative value of ocean bottom seismographs and surface ones for studying the rupture of a subduction zone event (Iida et al., BSSA, 1990 = Paper B).

At present, although a semi-permanent SM-OBS does not exist, temporary networks of SM-OBS systems are in the process of development. Since 1978, relatively low-cost seismic stations for measuring strong ground motion on the ocean bottom have been tested (Steinmetz et al., Offshore Technology Conference Proceedings, 1979; Steinmetz et al., Marine Geotechnol., 1981). These experiments indicate that an ocean bottom station is capable of recording ground accelerations up to about 1.0 g, in the 0.1 to 10 Hz frequency band.

3. METHODS

An overdetermined least-squares inversion scheme is used, where the spatial resolution is predetermined by the subfault size and the model variance is used as the accuracy of the source inversion (Paper B). Exactly speaking, the accuracy of the source inversion means the maximum standard deviation of all subfault moments. The accuracy of the source inversion is efficiently estimated by using Wolberg's prediction analysis (D. Van Nostrand Co., Inc., Princeton, 1967). We use exact solutions in a homogeneous halh-space.

4. ACTUAL EARTHQUAKES

The effectiveness of SM-OBSs installed within the offshore Tokachi-oki fault area is examined. SM-OBSs average the inversion uncertainty over the fault area, resulting in a decrease of the largest error. The SM-OBS deployment should be taken into account in future planning installations for offshore faults such as the 1968 Tokachi-oki event.

In the Tokai earthquake, the inversion uncertainty is greatly dependent on the direction of rupture propagation. We do not strongly recommend an installation of SM-OBSs in the fault area for this earthquake, since their effect is found to be unexpectedly small. Examined cases and the results for these two earthquakes are fully discussed in Paper A.

5. A GENERAL TEST

Fig. 1 shows the geometrical fault-array layout used in our study. Effects of the increasing numbers of surface stations and ocean bottom stations on the inversion uncertainty are displayed in Fig. 2. Interestingly, the inversion uncertainty does not appear to saturate as the number of surface stations is increased in the absence of OBSs. The graph suggests that effects of OBSs are not very dramatic. In this case, 1 OBS is worth about 4 surface stations. Considering difficulty in the design, deployment and maintenance for ocean bottom instruments, it is doubtful that our results are a strong incentive to deploy permanent OBSs in subduction zones.

The simulation also gives an interesting view concerning positions of OBSs. If we have only one instrument, it should be located on the opposite side to the land about the fault, not within the fault zone. In the case of two instruments, one should be deployed on the opposite side to the land while the other is within the fault zone above the fault. This indicates that azimuthal coverage is more important than proximity to the fault.

6. CONCLUSIONS

(1) The deployment of ocean bottom seismographs should be taken into account in future planning installations for offshore faults such as the 1968 Tokachi-oki earthquake fault. (2) We do not strongly recommend an installation of ocean bottom stations for the anticipated Tokai earthquake. (3) A general subduction zone simulation does not lead to a strong incentive to deploy permanent ocean bottom seismographs.

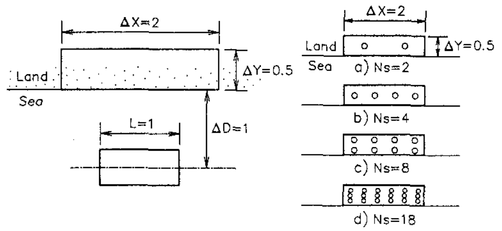

Fig.1 Geometrical arrangement for an offshore subduction thrust simulation. A pure dip-slip fault is assumed. The numbers of surface stations and ocean bottom stations, Ns and No are varied separately to estimate their influence. The distribution in the surface stations is fixed and forms a line or a rectangular grid. Several patterns of ocean bottom stations are tested for each pair of Ns and No.

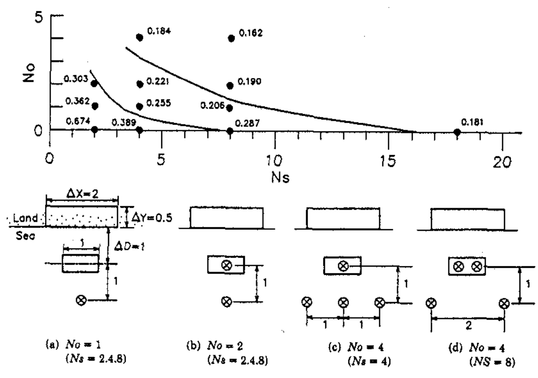

Fig.2 Relationship among the inversion uncertainty, σ, the numbers of surface stations and ocean bottom stations, Ns and No. The best positions of ocean bottom stations are depicted for each pair of Ns and No.